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(54) Method and system for monitoring an interior

(57) The invention relates to a method and a system for monitoring an interior. For detecting an object 3 trespassing into the interior a picture of the interior is compared with a previously taken background image showing the interior from the same angle when it is not disturbed by any trespassing object. A detecting means 30 takes a decision for detecting an object 3 trespassing into said interior in the case that there is a shadow 4', 4" caused by said trespassed object 3 in the picture covering at least a section of said interior. In order to reduce the effort for detecting the object 3 trespassing into the interior the present invention proposes not to evaluate shadows in any part of the picture but only that shadows which cover at least a part of a predetermined relevant area of the interior through which trespassing of an object is most likely expected.

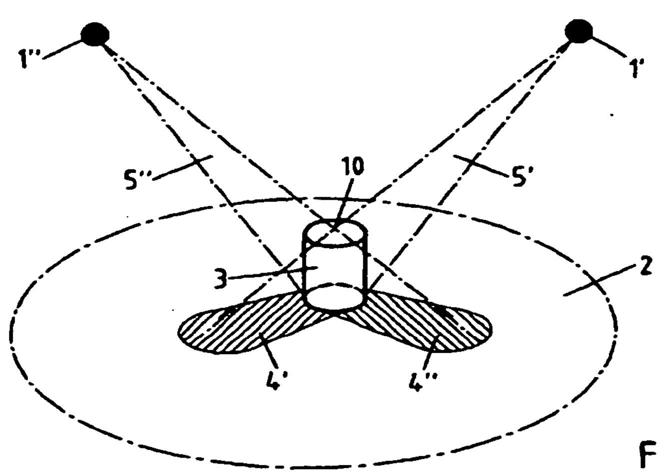

Fig.1

Description

[0001] The invention relates to a method for monitoring an interior, in particular the interior of a vehicle, and for locating an object trespassing into said interior. The method comprises the steps of: detecting an object trespassing into said interior in the case that there is a shadow caused by the trespassing object in a picture of the interior taken when monitoring it, determining the location of that section of the interior which has in the picture been covered by said shadow, and estimating the location of the trespassed object in the interior from said determined location of said section in the interior. The invention further relates to a system for carrying out said method.

[0002] Such methods and systems are known in the art.

[0003] Fig. 5 for example shows a three dimensional illustration of the principles known in the art on which the present invention is based. More specifically, Fig. 5 shows a monitored interior, for example of a vehicle, into which an object 3 has penetrated. The object sticks out through a monitored plain 2 of said interior.

[0004] In the case that the object 3 has entered the interior a shadow 4' caused by said object 3 is recognised in an infrared or radar picture taken by an optical image sensor 1' for monitoring the interior. Expressed in other words, the presence of the object 3 in the interior can be detected by the presence of a shadow 4' in said picture.

[0005] The location where said object 3 has penetrated into said interior can roughly be estimated when comparing said picture with a background image of said interior which has previously been taken by said optical image sensor 1' but not being disturbed by any penetrating object. More specifically, the location/position of the shadow 4' in said picture roughly indicates the location of the penetrating object in the interior.

[0006] Fig. 6 shows a system known in the art for carrying out the above described method. For detecting the object 3 penetrating into the interior the system comprises said fix-positioned optical image sensor 1' for monitoring said interior. Moreover, it comprises a storage means 20 for storing the pictures taken by said optical image sensor and in particular for storing the background image also taken by said optical image sensor.

[0007] The system further comprises detecting means 30 for comparing the picture with the background image and for detecting an object trespassing into said interior in the case that there is a shadow in the picture covering at least one part of the picture which in the case of no disturbance would show the corresponding part of said background image.

[0008] A quite similar method and system is for example known from DE 41 17 774 A1. Said document discloses a method for monitoring an area in order to detect and determine target objects in a sequence of images taken by a fixed positioned camera and evaluated by an evaluation circuit.

[0009] A first image taken by said camera is filtered and stored as a start background image in a background window storage means. The stored start background image is subsequently divided into a plurality of sectors having equal sizes. Each image subsequently taken by said camera is stored in an additional window storage means and like said start background image divided into the same number of sectors having the same size. Each sector of a subsequent image is correlated with the co-ordinated sector of said start background image. The results of said correlation process are used to roughly calculate the position of said target objects within said area.

[0010] Starting from that disclosure it is the object of the present invention to improve the method and the system for monitoring an interior and for locating an object trespassing into said interior in the way that a decision that an object has in fact trespassed into the interior is ensured.

[0011] Said object is solved by the subject matters of claims 1 and 9, respectively.

[0012] Starting from the method known in the art said object is solved by providing the criteria that a decision for the detection of the object is only taken, if the determined section is located in at least a part of a predetermined relevant area of the interior through which trespassing of an object into the interior is most likely expected.

[0013] According to the present invention a whole interior is monitored in order to recognize undesired objects including subjects trespassing into said interior. The monitored interior is subdivided into several predetermined areas being differently classified regarding the probability that trespassing of an object into the interior is expected. The areas of the interior considered to have a high probability that the trespassing of an object is expected through them are hereinafter referred to as relevant areas.

[0014] The quality of the infrared or radar pictures taken for monitoring the interior is often very bad with the result that not each shadow shown in the picture does in fact represent an undesired object which has trespassed into the interior. Consequently, a decision about the presence of an undesired object in the interior taken due to the existence of a shadow in the picture is uncertain.

[0015] In order to overcome that deficiency the decision is - according to the invention - only taken if the section of the interior covered by the shadow in the picture is located in at least a part of these predetermined relevant areas of the interior through which trespassing of an object into the interior is most likely expected. In that way the certainty of the decision is increased.

[0016] By defining that criteria the decision that an object has in fact trespassed into the interior is ensured because, to the contrary, trespassing of an object

through other less relevant areas of the interior is more unlikely or impossible.

[0017] According to a first embodiment of the invention it is advantageous that the relevant area is a window area or at least an area comprising an edge of a window since trespassing of an object through a window into the interior, in particular of a vehicle is most likely expected. To the contrary, trespassing of an object through less relevant areas like the ceiling or the floor of a vehicle, is less likely.

[0018] It is of particular interest that the determined section allows the conclusion that a part of the trespassing object has already entered the interior through the window area whereas simultaneously another cohesive part of the object still remains outside the vehicle. In that case it is assumed that parts of the body of a person (object), for example the head or an arm has trespassed into the interior of the vehicle for example through the window, whereas the remaining part of the body of the person is still outside of the vehicle. Such a shadow is quite different from a shadow of an object which has trespassed into the interior as a whole, for example a ball which has been thrown into the interior of the vehicle; such a shadow would only cover inward areas of the vehicle. In latter case it is assumed that the trespassing object is not a person since there is no part of the shadow covering external areas of the vehicle. In that way the form and location of the shadow in the picture allow conclusions about the trespassing object, in particular, as to whether a person or a thing has entered the interior.

[0019] It is advantageous that the determination of the location of the section in the interior comprises the step of comparing said picture with a background image showing the interior from the same angle as the picture but not being disturbed by any object which has trespassed into said interior.

[0020] It is further advantageous that the background image can be adapted to changes in the relevant area of the interior. The background image of the relevant section within the interior may be taken when a system for carrying out the method is primarily installed. However, in the case, that for example the interior of a vehicle is monitored the look of said window area may change, for example due to a seat belt which has not been coiled up correctly. In that situation it is important that said change in the look of the window area is not interpreted as a shadow caused by an object which has trespassed into the interior. Such a misinterpretation is advantageously avoided by providing and using an updated background image which has been adapted to changes in the relevant section of the interior. Advantageously the update is done during each restart of the alarm system according to the invention.

[0021] Advantageously an alarm signal is generated and forwarded to an alarm station upon the decision for the detection of an object within the interior has been taken.

[0022] Favourably the method is not only able to detect an object which has trespassed into the interior but also to determine its penetration into the interior.

[0023] The above defined object of the invention is further solved by a system for carrying out the method described above. The advantages of said system correspond to the advantages of said method.

[0024] The following figures accompany the description, wherein

Fig. 1	shows a 3-dimensional illustration of the method for detecting and locating an object trespassing into an interior according to the present invention;
Fig. 2	shows side-view of Fig. 1;
Fig. 3	shows a projection of Fig. 1 into a projecting plain shown in Fig. 2;
Fig. 4	shows a system according to the present invention.
Fig. 5	shows a 3-dimensional illustration of the principles known in the art on which the present invention is based.
Fig. 6	shows a system for carrying out the principles known in the art.

[0025] In the following a preferred embodiment of the invention is described in more detail by referring to figures 1 to 4.

[0026] Fig. 1 illustrates the principle of the present invention.

[0027] In order to monitor an interior, in particular the interior of a vehicle there is at least one optical image sensor 1' mounted to the body of the vehicle, for example to the ceiling of the vehicle from inside. The optical image sensor 1' takes radar or infrared pictures of an area 2 of the interior, preferably upon infrared flashing. Since trespassing of an undesired object 3 into the interior of the vehicle is a most likely expected through relevant areas of the interior like a window area 2 of the vehicle the optical image sensor 1' is preferably focused to said window area 2.

[0028] For only generally locating the trespassing object one optical image sensor 1' is sufficient. In the case that an undesired object 3 actually trespasses into the interior of the vehicle through said window area 2 it causes a shadow 4' in a picture taken by said optical image sensor 1'. Consequently, the existence of a shadow in a picture taken by said optical image sensor generally allows the conclusion that an object has entered the interior of the vehicle. Said shadow may in particular be recognised when comparing the picture with a background image of the same area of the interior which has previously also been taken by said optical

image sensor 1' from the same angle and which is not disturbed by any trespassing object.

[0029] However, in order to more precisely locate the penetrating object 3 according to the present invention a further optical image sensor 1" is provided for additionally monitoring said window area 2 from a different angle. The penetrating object 3 causes a further shadow 4" in a picture taken by said further optical image sensor 1" as shown in Fig. 1, irrespective as to whether the object 3 just sticks out through a plain spanned by the window area 2 or as to whether the object has already completely entered the interior (not shown). The more precise location of the penetrating object 3 can now be determined by calculating and evaluating the intersection of two fictitious lightening cones 5', 5". More specifically, these cones are fictitious truncated cones wherein the tip of each of said truncated cones is located in the centre of one of said optical image sensors 1', 1" and wherein these cones are restricted by the shadow 4', 4" being co-ordinated to said optical image sensor and acting as conic section, respectively. The location of the object 3 in the monitored area 2 of the interior is determined by the intersection 10 of said shadows 4' and 4". Moreover, penetration of the object into the interior is determined by the maximum distance of the intersection 10 of said truncated cones to the plain spanned by said window area 2.

[0030] The more precise determination of the location of the object and its penetration is now explained in more detail by referring to figures 2 and 3.

[0031] For improving the intelligibility of Fig. 3, auxillary Fig. 2 shows a side-view of the arrangement shown in Fig. 1. When the arrangement in Fig. 1 is looked at from the line of sight indicated by the arrow 7 in Fig. 2 one can imagine that it is projected onto a fictitious projecting area 6 shown in Fig. 2. Said projecting area 6 is preferably perpendicular to the monitored window area / plain 2 of the vehicle and preferably comprises the centres of said optical image sensors 1' and 1".

[0032] Fig. 3 represents a view onto said fictitious projecting area from the indicated line of sight. Consequently, the 3-dimensional illustration of Fig. 1 is reduced to a 2-dimensional illustration which facilitates explanation of the determination of the location and the penetration of the object.

[0033] Fig. 3 shows a cross-sectional view through a car body 8 of the vehicle wherein the external area 9' of the vehicle and its interior 9" consequently lie on opposite sides of said car body. The car body 8 comprises the window area 2 through which penetration of an object is most likely expected.

[0034] As already indicated above one optical image sensor is sufficient for estimating the location of a penetrated object, because its location can be estimated by evaluating the location of its shadow 4', 4" in a picture. The location of the shadow is in particular defined by its edge 4'a, 4"a, favourably indicated in Fig. 3 by a fictitious line 5'a, 5"a corresponding to the longest section of a line reaching from the centre of an optical image sensor 1', 1" to the furthermost point of the edge 4'a, 4"a of the respective shadow. Said fictitious line 5'a, 5"a may be considered as being part of the surface area of the truncated cones 5', 5" described in Fig. 1.

[0035] However, that estimation of the location of the object by its shadow is only a rough one when the window area 2 is wide in comparison to the width 3a of the penetrating object 3. As can be seen from Fig. 3 there are several possible locations 3, 3', 3" where the object 3 could have entered the window area. (see dotted and solid lines in Fig. 3). In all said different entry locations the object 3 would have caused the same furthermost point of the edge of the shadow.

[0036] Furthermore, the different possible locations 3, 3', 3" represent different penetrations P, P', P" of the object 3 into the interior of the vehicle, respectively.

[0037] In order to more precisely determine the location and the penetration of the object into said interior the present invention provides a further optical image sensor 1" for monitoring the window area 2 additionally from a different angle than sensor 1'. The trespassing object 3 will then additionally cause a further shadow 4" on a further picture taken by said further optical image sensor 1". When only considering said further picture and in particular evaluating fictitious line 5"a connecting the centre of said further optical image sensor 1" with the far edge 4a of shadow 4" a similar rough estimation about the location and penetration of the object 3 would be received as described above.

[0038] However, the locations of said optical image sensors 1' and 1" differ from each other and preferably monitor the window area 2 from opposite directions. Consequently, the fictitious lines 5'a and 5"a have an intersection 10, in particular when they are projected into the projecting plain.

[0039] As can be seen from Fig. 3 calculation and evaluation of said intersection 10 allows a more precise determination of the location of the trespassing object 3 (see object 3 drafted in solid lines) with regard to the width of said window area. More specifically, in the projecting plain there is only one location of the object 3 (drafted in solid lines) which is co-ordinated to said intersection; that specific location can be considered as the precise location where the object has actually entered the window area 2. Moreover, that specific location allows a more precise determination of the penetration P of the object.

[0040] Fig. 4 shows the system for carrying out the method according to the invention. It comprises at least the two fix-positioned optical image sensors 1, 1" for monitoring the interior from different angles, respectively. It further comprises a storage means 20 being adapted to store at least the two background images and / or the pictures taken by said two optical image sensors 1', 1", respectively. The pictures as well as their respective background images are provided to a detect-

ing means 20 which is able to compare and evaluate at least these two pictures and their respective background images. Said detecting means 30 takes a decision that an object 3 has trespassed into the interior (of the vehicle) only if the section of the interior covered in the picture by the shadow is at least part of a predetermined relevant area of the interior. Said detecting means may further comprise locating means (not shown) for estimating the location of the object.

[0041] The pictures and their respective background images may be further analysed in a calculating means 40 in order to more precisely determine the location and the penetration of said object 3 in the interior. More specifically, said calculating means 40 is adapted to calculate the penetration of the trespassing object 3 into the interior or the distance between the trespassing object and at least of said optical image sensors by evaluating the intersection 10 of the fictitious truncated cones 5', 5" or of the fictitious lines 5'a, 5"a mentioned above.

[0042] The invention has substantially been described by referring to the interior of the vehicles, but it shall be pointed out that the principles claimed in the present invention are further applicable to other interiors.

Claims

1. Method for monitoring an interior, in particular the interior of a vehicle, and for locating an object (3) trespassing into said interior, comprising the steps of:

    detecting an object (3) trespassing into said interior in the case that there is a shadow (4') caused by the trespassing object (3) in a picture of the interior taken when monitoring it;

    determining the location of that section of the interior which has in the picture been covered by said shadow (4'); and

    estimating the location of the trespassed object (3) in the interior from said determined location of said section in the interior;
    characterized in that

    a decision for the detection of the object (3) is only taken, if the determined section is located in at least a part of a predetermined relevant area (2) of the interior through which trespassing of an object (3) into the interior is most likely expected.

2. Method according to claim 1 **characterized in that** the predetermined relevant area (2) is a window area or at least an area comprising an edge of a window.

3. Method according to claim 2, **characterized** in that the decision for the detection is only taken, if the determined section allows the conclusion that a part of the trespassing object (3) has already entered the interior through the window area (2) whereas simultaneously another cohesive part of the object still remains outside the vehicle in front of the window area.

4. Method according to one of the preceding claims **characterized in that** the step of determinating the location of the section comprises the step of comparing said picture with a background image showing the interior from the same angle as the picture but not being disturbed by any object (3) which has trespassed into said interior.

5. Method according to claim 4, **characterized in that** said background image is adapted to changes in the interior upon each restart of a system for carrying out the method.

6. Method according to one of the preceding claims, **characterized in that** an alarm signal is generated upon the decision for the detection has been taken.

7. Method for determining the penetration of an object trespassing into an interior, comprising the steps of:

    carrying out the method according to one of claims 1 to 6 at least twice wherein the pictures are taken from different angles, respectively;

    selecting for each of said angles preferably the longest section of a line (5'a, 5"a) in the interior or in the surface area of a respective fictitious truncated cone (5', 5") the tip of which lies in the centre of an optical image sensor (1', 1") taking the pictures and which is restricted by the area of the shadow (4', 4") in the respective picture acting as conic section;

    projecting said selected lines (5'a, 5"a) into a projecting area (6) substantially perpendicular to the area of the taken pictures and comprising at least the centre of one optical image sensor; and

    calculating the perpendicular distance of the intersection 10 of said lines to the area of the taken pictures, wherein said distance represents the penetration (P) of the object into the interior.

8. Method for determining the penetration of an object into the interior of a vehicle, comprising the steps of:

carrying out the method according to one of claims 1 to 6 at least twice, however taking the pictures from different angles, respectively;

determining a fictitious truncated cone (5', 5") for each of said shadows, the tip of said cone lying in the centre of the optical image sensor (1', 1") and the cone being restricted by the area of the shadow in the picture acting as conic section, respectively;

determining the intersection (10) of said fictitious truncated cones; and

calculating the maximal perpendicular distance of said intersection (10) to the area of the taken pictures, wherein said distance represents the penetration of the object into the interior or calculating the distance from said intersection to at least one of the centres of said angles.

9. System for monitoring an interior, in particular the interior of a vehicle, and for locating an object (3) trespassing into the interior, the system comprising:

a fix-positioned optical image sensor (1') for taking a background image and a picture of the interior wherein the background image has been taken before said picture and is not disturbed by any trespassing object; and

a storage means (20) for storing at least said background image;

a detecting means (30) for detecting an object trespassing into said interior in the case that there is a shadow (4') in said picture, the shadow being caused by said object (3) and covering at least a section of said interior in the picture; and

a locating means for estimating the location the object in the interior by determining the location of said section caused by said object in the picture;
characterised in that

said detecting means (30) is adapted to take a decision for the detection of the object only if the located section is located in at least a part of a predetermined relevant area (2) of the interior through which trespassing of an object into the interior is most likely expected.

10. System according to claim 9, **characterized in that** the locating means comprises a comparing means (40) for comparing said picture with a background image showing the interior from the same angle as the picture but not being disturbed by any object which has trespassed into said interior.

11. System according to claim 9 or 10, **characterized in that**

the system comprises at least one further fix-positioned optical image sensor (1") for monitoring the interior from a different angle and for taking a further background image and a furter picture of the interior from said different angle;

said storage means (20) is adapted to further store at least the further background image;

said locating means are adapted to additionally estimating the location of the object by evaluating at least one further picture and background image of the interior; and

a calculating means (40) is adapted to calculate the penetration of the trespassing object (3) into the interior or the distance between the trespassing object and at least one of said optical image sensors (1', 1") by evaluating the intersection of fictitious truncated cones or lines within these cones, wherein the tip of each of said cones is assumed to lie in the centre of one of said optical image sensors whereas the bottom of a cone is assumed to be represented by the shadow hidden for the respective optical image sensor, respectively.

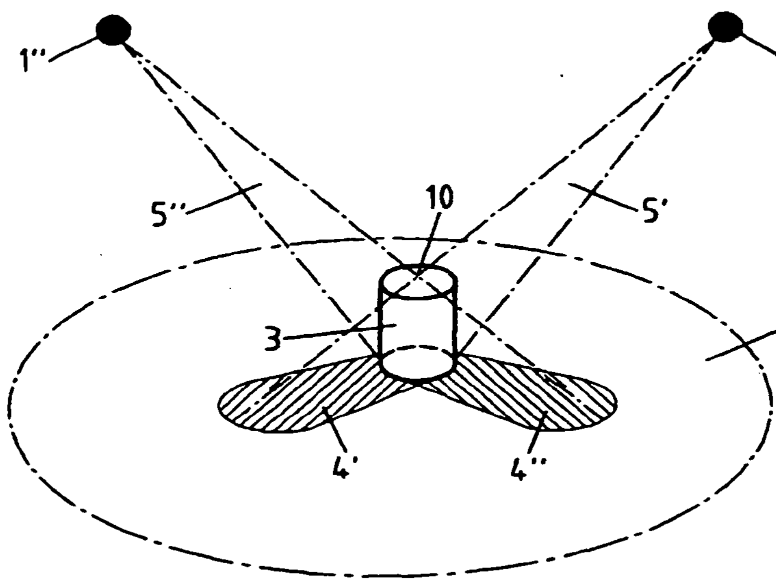

Fig.1

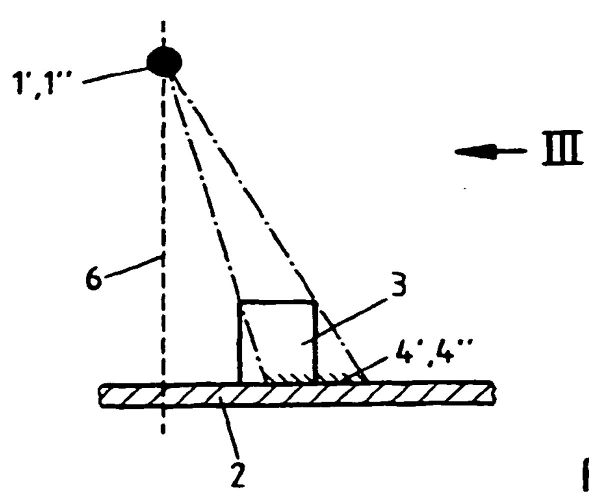

Fig.2

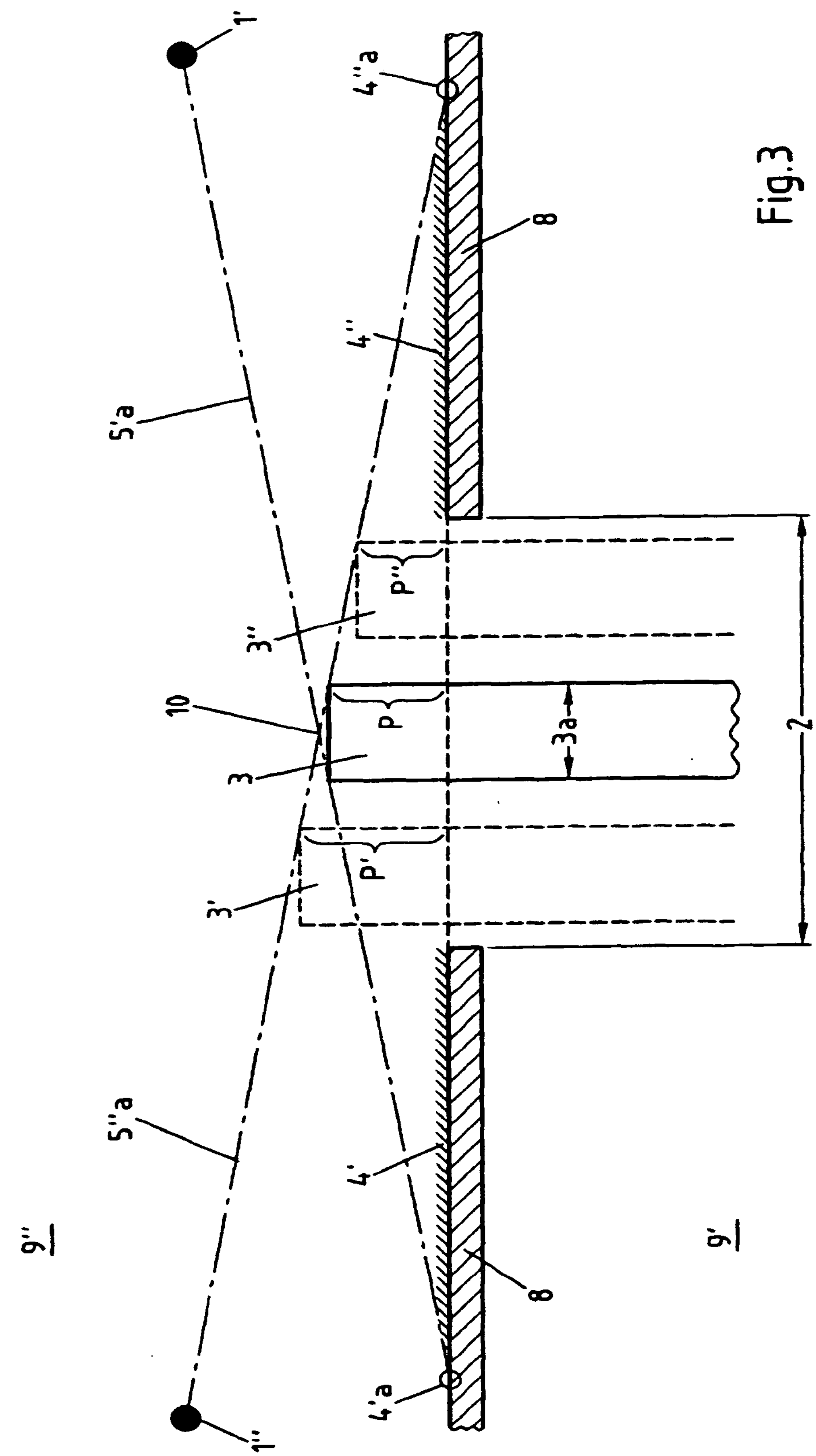

Fig.3

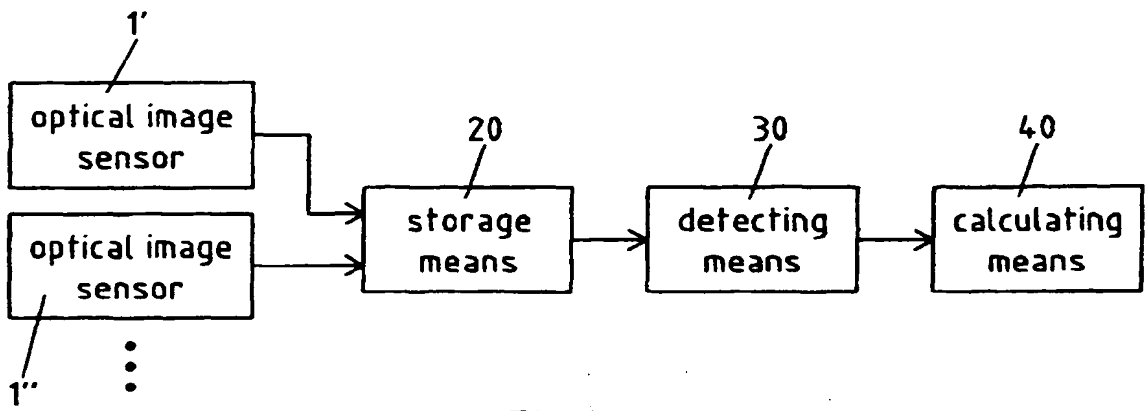

Fig.4

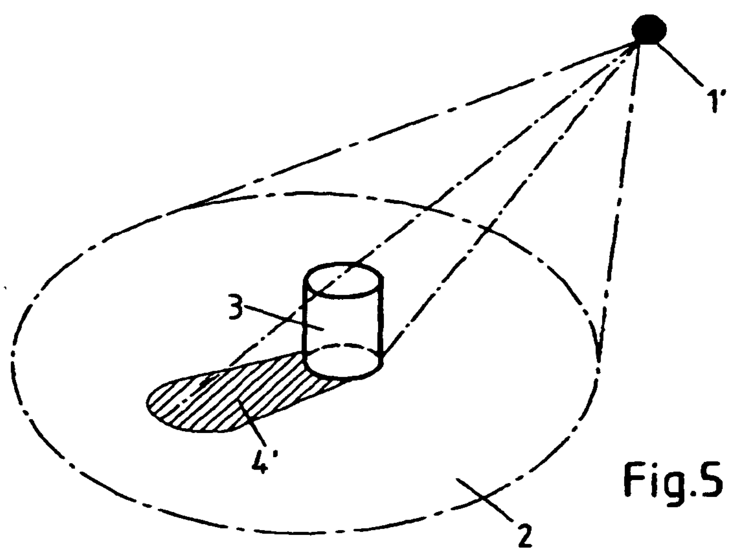

Fig.5 Stand der Technik

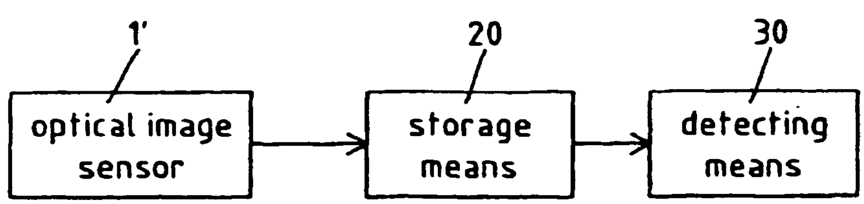

Fig.6 Stand der Technik